Infectious risk moments: a novel, human factors-informed approach to infection prevention

Clack, Lauren ; Schmutz, Jan ; Manser, Tanja ; Sax, Hugo

Abstract: We pilot tested a novel human factors-informed concept to identify infectious risk moments (IRMs) that occur with high frequency during routine intensive care. Following 30 observation-hours, 28 potential IRMs related to hand hygiene, gloves, and objects were expert rated. A comprehensive IRM inventory may provide valuable taxonomy for research, training, and intervention.

DOI: https://doi.org/10.1086/677166

Infectious Risk Moments: A Novel, Human Factors—Informed Approach to Infection Prevention

Author(s): Lauren Clack, BSc; Jan Schmutz, MSc; Tanja Manser, PhD; Hugo Sax, MD

Source: *Infection Control and Hospital Epidemiology*, Vol. 35, No. 8 (August 2014), pp. 1051-1055

Published by: The University of Chicago Press on behalf of The Society for Healthcare Epidemiology of America

Stable URL: http://www.jstor.org/stable/10.1086/677166

CONCISE COMMUNICATION

Infectious Risk Moments: A Novel, Human Factors–Informed Approach to Infection Prevention

Lauren Clack, BSc;[1] Jan Schmutz, MSc;[2] Tanja Manser, PhD;[3] Hugo Sax, MD[1]

We pilot tested a novel human factors–informed concept to identify infectious risk moments (IRMs) that occur with high frequency during routine intensive care. Following 30 observation-hours, 28 potential IRMs related to hand hygiene, gloves, and objects were expert rated. A comprehensive IRM inventory may provide valuable taxonomy for research, training, and intervention.

Infect Control Hosp Epidemiol 2014;35(8):1051-1055

Healthcare-associated infections (HAIs) are a major threat to patient safety on a global level. Repeatedly, scientific publications report extraordinary reductions of HAI rates in areas such as central line–associated bloodstream infections, ventilator-associated pneumonias, and urinary tract infections.[1,2] Almost exclusively, these interventions target procedures with high per-procedure likelihood of HAI in case of procedural noncompliance.

Hands of healthcare workers (HCWs) are the most common vehicles for transmission of pathogens in hospital settings.[3] Thus, hand hygiene has been widely accepted as the leading measure for preventing HAI.[4] Each individual hand hygiene indication, however, represents a low-likelihood opportunity for transmission. Instead, the substantial overall risk on a system level lies in the cumulative high frequency of hands touching surfaces and patients, successively.

While hand hygiene is certainly a crucial measure to prevent transmission of HAIs, evidence suggests that transmission and infection occur as a result of additional unsafe moments during care.[5-10] In consequence, we propose a novel, human factors–informed infection prevention concept. This concept suggests that infectious risk resides to a considerable proportion in seemingly innocent but frequent care-related manipulations at infectious risk moments (IRMs) that include—yet go beyond—indications for hand hygiene. We do this in the line of thought that led to the creation of the "My 5 moments for hand hygiene" concept,[11] utilizing human factors principles to incorporate a systems approach and increase chances for effectiveness and implementation success. Human factors is the interdisciplinary field that aims to optimize interactions between humans and their work environment in order to minimize errors, promote human well-being, and ultimately improve overall system performance (http://www.iea.cc/whats/index.html).

This pilot study was conducted in a cardiovascular intensive care unit at the University Hospital Zurich. We aimed to test the feasibility of identifying and rating the risk associated with potential IRMs according to frequency of IRM occurrence and the associated likelihood of an infectious patient outcome, that is, colonization or infection.

METHODS

Definition of IRMs. IRMs are defined as time spans in the workflow of HCWs that are associated with a risk of patient colonization or infection. At any single IRM, HCW behavior may be safe or unsafe. When HCWs display safe behaviors at IRMs, they mitigate the risk. We distinguish the 2 infectious patient outcomes: colonization (usually with multidrug-resistant pathogens) and infection.

Sensitizing of observers. The observers—2 researchers with extensive experience in human factors and observation in healthcare (L.C., J.S.)—held several rounds of discussion with a senior infectious diseases clinician (H.S.) and read core literature on this topic. The aim of this process was to enable the observers to recognize a broad range of potential IRMs.

Observations. The scope of observations was to identify a comprehensive listing of potential IRMs deductively (on the basis of known transmission pathways and infectious disease pathophysiology) and inductively (using a systems perspective to identify previously undetected IRMs in the workflow). The observers (L.C., J.S.) each spent approximately 20 hours conducting observations in the intensive care unit. They took field notes and transcribed potential IRMs as short narratives (Table 1). IRMs were collected independently of safe or unsafe HCW behavior. Sessions typically lasted 2–3 hours. The first 5 of 29 hours served as time for the intensive care unit staff to become accustomed to the presence of the observers, thereby diminishing the Hawthorne effect and allowing observers to gain understanding of care processes in this specific ward. Additionally, this time allowed the observers to gain understanding of the patient care processes in this specific ward. After every observation session, the research team discussed results to guarantee common understanding of the IRM concept. The observers sought a broad variety of care scenarios, typically including activities such as patient arrivals from the operating theater, in- and extubations, ultrasound examinations, and dressing changes. The researchers established a categorical frequency estimate for each IRM (ie, occurring less than hourly, approximately hourly, more than hourly).

Risk rating of IRMs. We chose an adapted Delphi method[12] to establish the likelihood of infectious patient outcomes of each observed IRM separately for colonization with multidrug-resistant microorganisms and infection. A purposeful sample of 9 infectious diseases and infection control clinicians with at least 3 years of specialized experience served as an expert panel. First, panel participants independently rated each potential IRM on a 5-item likelihood scale ranging

TABLE 1. Infectious Risk Moments (IRMs) with Likelihood Ratings and Frequency Estimates

IRM	Likelihood of transmission of MDR microorganisms[a]	Likelihood of HAI[a]	Frequency of occurrence[b]
Hand hygiene			
Approaching patient with new infusion bag without hand hygiene, then connecting bag to vascular access line	3	2	2
Rubbing one's own nose, then touching patient without intermittent hand hygiene	3	2	3
Wiping mouth of coughing patient, then connecting new infusion bag without hand hygiene	2	1	1
Inserting feeding tube through nose of patient, then touching patient and patient surroundings (ie, monitor and bedside table) without hand hygiene	2	1	1
Alternating between touching bedside touchscreen and touching patient without hand hygiene, given fact that touchscreen is frequently touched by other HCWs coming from hospital environment (eg, to silence an alarm) without hand hygiene	2	1	3
Alternating between writing in patient chart and touching patient without hand hygiene, given fact that chart is frequently touched by other HCWs coming from hospital environment without hand hygiene	2	1	3
Touching bedrail and then patient without hand hygiene after another HCW coming from hospital environment and touching bedrail without prior hand hygiene	2	1	2
Wheeling ultrasound machine next to patient bed, then alternating between using machine's keyboard and touching patient's abdomen without intermittent hand hygiene	2	1	1
Leaving patient to get dressing, cutting it to right size outside patient zone, then returning to patient and applying dressing to patient, all without hand hygiene	2	1	2
Touching one's private mobile phone and then patient without intermittent hand hygiene	2	1	3
Using private pen for note, then touching patient without intermittent hand hygiene	2	1	3
Touching one's own eyes and then patient without hand hygiene	2	1	3
Displacing towel covering patient from one body site to another without prior hand hygiene	2	0	1
Leaving patient to get new towel from closet, applying it to patient without hand hygiene	1	0	2
Touching shoulder of colleague during discussion, then touching patient without hand hygiene	1	0	2
People bumping into each other because of restricted space while caring for patient, then touching patient	1	0	2
Touching patient's monitor after contact with another patient without hand hygiene in-between	0	1	3
Glove use			
Three HCWs transporting patient from operating theater arrive with gloves on; they proceed to install patient—connecting medication, infusion, and ventilation—without any change of gloves	2	1	2
Three HCWs transporting patient from operating theatre arrive with gloves on; they proceed to install patient—connecting medications, infusions, and ventilation—without any change of gloves and also touch central venous line insertion site	4	3	1
Three HCWs transporting patient from operating theatre arrive with gloves on; they proceed to install patient—connecting medication, infusion, and ventilation—without any change of gloves and also accidently touch connection points of ventilator tubes	3	2	2
Disinfecting donned gloves before touching patient[c]	0	0	1
Object handling			
Using ultrasound scanner head on consecutive patients without cleaning	4	1	1
Reconnecting Y-tube of ventilation circuit after it fell to the floor without cleaning	3	2	1
Infusion tubes falling to the ground while being connected to patient during arrival, then consequently being put back on bed without cleaning	2	1	2
Dropping bottle from patient table and placing it back without cleaning	2	1	1
Placing bed linens (or other patient belongings) on windowsill and then to patient (HCWs often sit on ledge in times of low workload)	1	0	2
Putting towel on bed for a while after having used it on patient[c]	0	0	2
After attending to influenza patient isolated for droplet precautions, removing one's gown and shaking it out near patient before folding it[c]	0	0	1

NOTE. To make the likelihood of infectious patient outcome clear to the rating experts, IRMs always indicated unsafe behavior. HAI, healthcare-associate infection; HCW, healthcare worker; MDR, multidrug resistant.

[a] Likelihood ratings for infectious patient outcomes according to the Delphi method, with 9 infectious diseases/infection control experts: 0, nil; 1, low; 2, medium; 3, high; 4, very high.

[b] Semiquantitative rating of observed frequency: 1, less than hourly; 2, hourly; 3, more than hourly.

[c] Likelihood rating being nil for both infectious outcomes, these potential IRMs were not retained as such.

from 0 (nil) to 4 (very high), balancing granularity against overprecision. Then, results were compared during a group meeting, and inconsistencies were discussed until consensus was reached.

Ethics. The ethics review board of the State of Zurich waived the necessity for ethics review because of the quality improvement approach of this assessment (KEK-StV-Nr. 06/13).

RESULTS

Observations resulted in 28 distinct potential IRMs. We distinguished 3 categories for IRMs, namely those associated with hand hygiene, glove use, or objects. Table 1 provides the full list of observed IRMs and their corresponding likelihood rating and frequency estimate. The Delphi process resulted in an overall mean rating of 0.93 (standard deviation, 0.74) for the likelihood of infection and 1.87 (standard deviation, 1.04) for the likelihood of colonization with multidrug-resistant microorganisms. Overall, the likelihood rating for colonization was higher than for infection, with the latter being rated nil in 8 cases. Three potential IRMs received the rating nil for both colonization and infection and consequently did not qualify as IRMs. Figure 1 displays the distribution of all validated IRMs in a frequency/likelihood matrix.

DISCUSSION

In line with our hypothesis, experts rated the likelihood of infectious outcome due to unsafe behavior at IRMs mostly low, with a lower likelihood of infection than colonization. The cumulative risk of negative outcomes following these seemingly harmless manipulations becomes substantial because of their high frequency on a system level. While this concept is not new in other fields concerned with risk management, to our knowledge this is the first time such an approach has been applied to infection control. It is a complementary extension of the classical infection control hot spots associated with a higher risk density, such as the insertion of central venous catheters.[13] This study illustrates that IRMs go beyond established indications for hand hygiene to include moments when glove use and physical objects may be associated with infectious outcomes. These dimensions have not previously been included in an overarching concept. The resulting IRM concept reflects the overall microbiological risk of a care environment and its behavioral dimension from a system-wide perspective. This is of practical value in various ways.

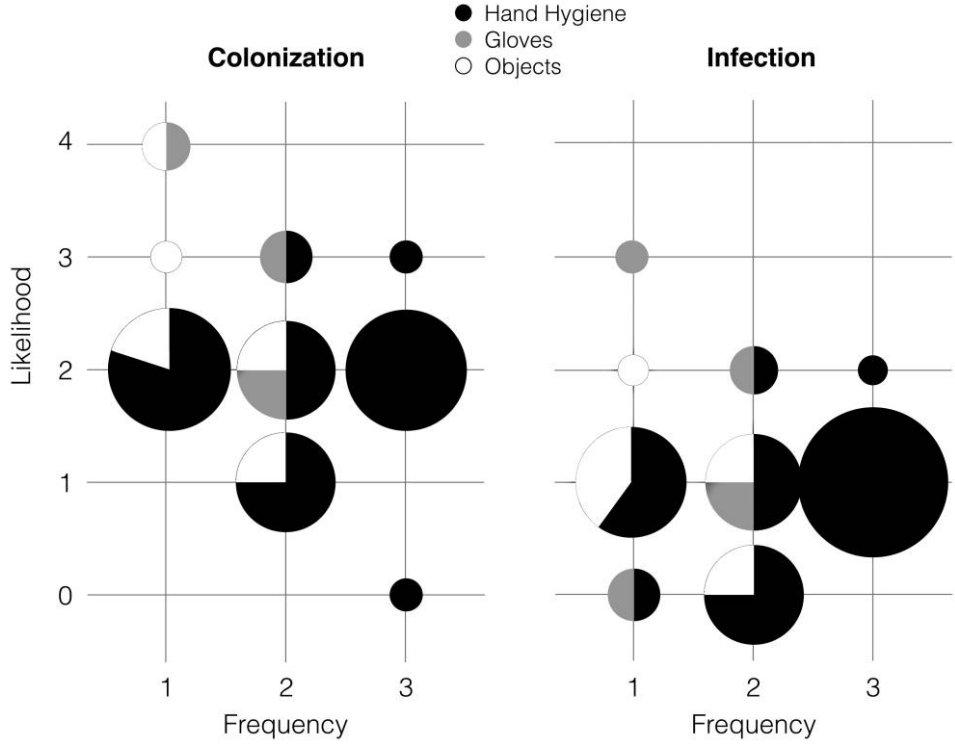

FIGURE 1. Likelihood/frequency matrix for infectious risk moments (IRMs). Frequency, semiquantitative rating of observed frequency: 1, less than hourly; 2, approximately hourly; 3, more than hourly. Likelihood, likelihood of an infectious patient outcome, that is, colonization or infection: 0, nil; 1, low; 2, medium; 3, high; 4, very high. Classification of IRMs: black, hand hygiene; gray, glove use; white, objects/cleaning. Numbers of distinct, observed IRMs are represented by the size of the pie charts.

A comprehensive IRM inventory provides a basis for further patient safety initiatives. Educational interventions would most likely benefit from a systematic taxonomy, helping to establish a more global perception of infectious risks in patient care. Most importantly, the IRM concept provides practical opportunities through understanding of risk perception.[14] Risk is typically defined as a product of the likelihood of an event and the magnitude of its consequences.[15] We did not address the magnitude of consequences but estimated instead the frequency at which the IRM occurs. An IRM of high frequency/low likelihood and 1 of low frequency/high likelihood would possess similar probabilities of infectious patient outcomes. If HCWs perceive only the risk associated with isolated IRMs, they will underestimate the overall consequences of unsafe behavior. The IRM concept lays the groundwork for future inquiry into HCW perception of risk and determinants of behavior at these moments in order to ultimately inform tailored interventions.[14,16-18]

Several limitations apply to this study largely because it was designed as a pilot to assess the feasibility of a larger project. The IRMs collected so far reflect a specific setting based on limited observations. Sampling saturation has neither been sought nor reached. Additional IRMs may be identified with extended time in the field and inclusion of additional settings. Moreover, while IRM frequency was only estimated, a future study would need to include structured quantitative observations to measure IRM frequency. Finally, the risk rating was limited in participants and cycles, and as mentioned before, the panel did not evaluate the magnitude of negative consequences following unsafe behavior during IRMs.

Other challenges, such as observer biases, are intrinsic to this type of research and will persist in a larger study. Involving multiple observers, investing in extensive observer training with frequent reflective discussions certainly helped to mitigate this potential bias.[19] Further, the lack of microbiological investigation in this study could be considered a limitation. Such testing, however, would be unfeasible, given the vast number of variables to be considered in the given scenarios. In light of this challenge, others investigating the transmission of infectious diseases have turned to agent-based modeling and simulations.[20] For our pilot study, we have looked to specialists in this domain to provide expert assessment of such risks.

In conclusion, this pilot study confirmed our hypothesis that a wide range of IRMs can be observed during routine patient care. The majority of IRMs concerned moments of hand hygiene, but others were linked to glove use and objects. On the basis of these results, building a comprehensive IRM inventory appears feasible. Such an inventory together with the proposed conceptual underpinning may help to advance the field of infection prevention by providing a standardized taxonomy for research, training, intervention, and evaluation.

ACKNOWLEDGMENTS

We would like to thank the healthcare workers in the cardiovascular intensive care unit at the University Hospital of Zurich, Switzerland, for their participation in this study and their continuous efforts for better patient care, especially Gabi Brenner, RN, and Bernard Krueger, MD. We also thank Marie-Therese Meier, RN, of the University Hospital of Zurich infection control team for her support.

Financial support. This work was partially funded by an institutional grant from the University Hospital of Zurich's Quality Management and Patient Safety Program.

Potential conflicts of interest. All authors report no conflicts of interest relevant to this article. All authors submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and the conflicts that the editors consider relevant to this article are disclosed here.

Affiliations: 1. Division of Infectious Diseases and Infection Control, University Hospital of Zurich, Zurich, Switzerland; 2. Industrial Psychology and Human Factors, Department of Psychology, University of Fribourg, Fribourg, Switzerland; 3. Institute for Patient Safety, University of Bonn, Bonn, Germany.

Address correspondence to Hugo Sax, MD, Division of Infectious Diseases and Infection Control, University Hospital of Zurich, Raemistrasse 100, Zurich 8091, Switzerland (hugo.sax@usz.ch).

Received December 14, 2013; accepted March 29, 2014; electronically published June 20, 2014.

 0899-823X/2014/3508-0017$15.00. DOI: 10.1086/677166

REFERENCES

1. Harbarth S, Sax H, Gastmeier P. The preventable proportion of nosocomial infections: an overview of published reports. *J Hosp Infect* 2003;54(4):258–266.
2. Umscheid CA, Mitchell MD, Doshi JA, Agarwal R, Williams K, Brennan PJ. Estimating the proportion of healthcare-associated infections that are reasonably preventable and the related mortality and costs. *Infect Control Hosp Epidemiol* 2011;32(2):101–114.
3. Pittet D, Allegranzi B, Sax H, et al. Evidence-based model for hand transmission during patient care and the role of improved practices. *Lancet Infect Dis* 2006;6(10):641–652.
4. Pittet D, Allegranzi B, Boyce J; World Health Organization World Alliance for Patient Safety First Global Patient Safety Challenge Core Group of Experts. The World Health Organization Guidelines on Hand Hygiene in Health Care and their consensus recommendations. *Infect Control Hosp Epidemiol* 2009;30(7):611–622.
5. Bonten MJ, Hayden MK, Nathan C, et al. Epidemiology of colonisation of patients and environment with vancomycin-resistant enterococci. *Lancet* 1996;348(9042):1615–1619.
6. Schabrun S, Chipchase L. Healthcare equipment as a source of nosocomial infection: a systematic review. *J Hosp Infect* 2006; 63(3):239–245.
7. Huang SS, Datta R, Platt R. Risk of acquiring antibiotic-resistant bacteria from prior room occupants. *Arch Intern Med* 2006; 166(18):1945–1951.
8. Hill C, King T, Day R. A strategy to reduce MRSA colonization of stethoscopes. *J Hosp Infect* 2006;62(1):122–123.
9. de Gialluly C, Morange V, de Gialluly E, Loulergue J, van der Mee N, Quentin R. Blood pressure cuff as a potential vector of pathogenic microorganisms: a prospective study in a teaching hospital. *Infect Control Hosp Epidemiol* 2006;27(9):940–943.

10. Longtin Y, Schneider A, Tschopp C, et al. Contamination of stethoscopes and physicians' hands after a physical examination. *Mayo Clin Proc* 2014;89(3):291–299.
11. Sax H, Allegranzi B, Uckay I, Larson E, Boyce J, Pittet D. "My five moments for hand hygiene": a user-centred design approach to understand, train, monitor and report hand hygiene. *J Hosp Infect* 2007;67(1):9–21.
12. Gordon TJ, Glenn JC. An introduction to the Millennium Project. *Technol Forecast Soc* 1994;47(2):147–170.
13. Slovic P. *The Perception of Risk*. London: Earthscan, 2000.
14. Tversky A, Kahneman D. Availability: a heuristic for judging frequency and probability. *Cogn Psychol* 1973;5(2):207–232.
15. Kasperson RE, Renn O, Slovic P, et al. The social amplification of risk: a conceptual framework. *Risk Anal*1988;8(2):177–187.
16. Skinner B. A case history in scientific method. *Am Psychol* 1956; 11(5):221.
17. Renn O. Risk perception: a systematic review of concepts and research results. In: *Avoiding and Managing Environmental Damage from Major Industrial Accidents*. Proceedings of the Air Pollution Control Association International Conference; November 1985; Vancouver, British Columbia. Pittsburgh, PA: Air Pollution Control Association, 1986:377–408.
18. Slovic P, Peters E. Risk perception and affect. *Curr Direct Psychol Sci* 2006;15(6):322–325.
19. Gurses AP, Murphy DJ, Martinez EA, Berenholtz SM, Pronovost PJ. A practical tool to identify and eliminate barriers to compliance with evidence-based guidelines. *Jt Comm J Qual Patient Saf* 2009;35(10):526–532.
20. Barnes S, Golden B, Wasil E. Exploring the effects of network structure and healthcare worker behavior on the transmission of hospital-acquired infections. *IIE Trans Healthcare Syst Eng* 2012;2(4):259–273.